SECURITY INFORMATION

[redacted]

Copy 5
RM L51I22a

JAN 7 1952

RM L51I22a

NACA

RESEARCH MEMORANDUM

WIND-TUNNEL INVESTIGATION AT TRANSONIC SPEEDS OF A LEADING-EDGE SLAT ON A MODIFIED-DOUBLE-WEDGE WING

By Richard G. MacLeod

Langley Aeronautical Laboratory
Langley Field, Va.

CLASSIFICATION CANCELLED

Authority Naca Res. abs. + Date 10-18-56
RN-108
By NB 11-5-56 See

CLASSIFIED DOCUMENT

This material contains information affecting the National Defense of the United States within the meaning of the espionage laws, Title 18, U.S.C., Secs. 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

December 26, 1951

[redacted]

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

WIND-TUNNEL INVESTIGATION AT TRANSONIC SPEEDS OF A LEADING-EDGE SLAT ON A MODIFIED-DOUBLE-WEDGE WING

By Richard G. MacLeod

SUMMARY

An investigation was made in the Langley high-speed 7- by 10-foot tunnel to determine the incremental maximum lift coefficient obtainable on a 6.3-percent-thick modified-double-wedge wing having a taper ratio of 0.63 and an aspect ratio of 2.5 by deflecting a leading-edge slat 40°. The investigation was made through the transonic speed range by testing in the high-velocity field over a reflection plane on the side wall of the tunnel. The Reynolds number of the tests was approximately 1×10^{6}.

The results of the investigation indicated that the maximum lift coefficient was increased approximately 50 percent over that of the plain wing at a Mach number of 0.6 by the deflection of the slat, but the increase obtained almost disappeared as a Mach number of 1.00 was reached.

INTRODUCTION

The maximum-lift capabilities of aircraft wings at high speeds are becoming of greater importance as the speeds and altitudes flown by modern aircraft continue to increase. High-speed, high-altitude aircraft are being flown at rather high lift coefficients and may reach or exceed the angle of attack for maximum lift of the aircraft in maneuvers. High-lift devices have substantially increased the maximum lift obtainable at low speeds. The twofold purpose of this investigation was to determine the feasibility of attaching a simple leading-edge slat designed for operation on a two-dimensional wing (reference 1) to a low-aspect-ratio wing and to determine whether the high lift increment obtainable at low Mach numbers by the addition of this slat was maintained through the transonic speed range.

[redacted]

COEFFICIENTS AND SYMBOLS

The forces and moments measured on the wing are presented about the wind axes, which, for the conditions of these tests (zero yaw), correspond to the stability axes. The axes meet at the intersection of the chord plane and the 50-percent station of the root chord of the model (figs. 1 and 2).

The symbols used in the presentation of the results are as follows:

C_L lift coefficient (Twice lift of semispan model/qS)

C_D drag coefficient (Twice drag of semispan model/qS)

C_m pitching-moment coefficient (Twice pitching moment of semispan model/$qS\bar{c}$)

q effective dynamic pressure over span of model, pounds per square foot $\left(\frac{1}{2}\rho V^2\right)$

S twice wing area of semispan model, 0.183 square foot

b twice span of semispan model, 0.675 foot

$\bar{c}$ mean aerodynamic chord of wing, 0.276 foot based on relationship $\frac{2}{S}\int_0^{b/2} c^2\,dy$

c local wing chord, feet

y spanwise distance from plane of symmetry, feet

ρ mass density of air, slugs per cubic foot

V free-stream air velocity, feet per second

M effective Mach number over span of model

R Reynolds number of wing based on $\bar{c}$

α angle of attack, degrees referred to wing-root-chord line

Subscript:

max maximum

APPARATUS AND TESTS

The investigation was conducted in the Langley high-speed 7- by 10-foot tunnel. The two models used in the investigation both had the same plan-form dimensions: taper ratio 0.63, aspect ratio 2.5, and a 6.3-percent-thick modified-double-wedge section (fig. 2). The wing with the 24-percent-chord, full-span, leading-edge slat was steel and the plain wing was aluminum. These models were mounted on a reflection-plane plate located 3 inches from the tunnel wall in order to bypass the wall boundary layer (reference 2). The aerodynamic forces and moments on the model were measured about the 0.50-root-chord position with an electrical strain-gage balance which was sealed in a container on the tunnel side wall in order to prevent air flow around the model from the outside test chamber to the test section. A sponge-rubber seal was fitted to the reflection plane at the model plane of symmetry to minimize air-flow circulation that might develop through the small gap which separated the model from the reflection plane.

At Mach numbers below 0.95 there was practically no velocity gradient in the vicinity of the reflection plane. At higher Mach numbers, however, the presence of the reflection plane created a high-local-velocity field which allowed testing small models up to $M = 1.10$ before choking occurred in the tunnel. The aerodynamic characteristics were determined through a Mach number range from 0.60 to 1.10 and through an angle-of-attack range between -10° and 50°. The variation of test Reynolds number with Mach number for average test conditions is presented in figure 3.

CORRECTIONS

No jet-boundary, blocking, or buoyancy corrections have been applied to the data because of the small size of the model as compared with the size of the tunnel test section. No corrections have been applied to the data to account for the small misalinement of the air stream. The structural deflection of the steel and aluminum models was considered to be small and was neglected.

DISCUSSION

Figure 4 presents the aerodynamic characteristics of the test model throughout the angle-of-attack range for both the plain wing and the wing with the leading-edge slat deflected 40°. The 40° slat-deflection angle was chosen because it appeared to offer the best maximum-lift possibilities for this configuration as seen from some low-speed two-dimensional data (reference 1), even though it was realized that two-dimensional data would not be directly applicable to this model.

The lift curves (fig. 4(a)) appeared to be quite erratic with the slat deflected, particularly in the low Mach number range. A considerable decrease in the lift-curve slope was observed up to a Mach number of 1.00 when the slat was deflected. The maximum lift increase with slat deflection was obtained by extending the stall angle which increases with increasing Mach number up to a value of approximately 0.95. It may be noted here that even at the highest Mach number tested (1.10) the slat still increases the stall angle in much the same manner as at low speeds although there is very little gain in maximum lift. Because of the double break in the lift curve peculiar to this type of wing, the angle of attack for maximum lift is very erratic for the plain wing as the Mach number is increased.

The drag and pitching-moment curves, figures 4(b) and 4(c), show approximately the trends expected when the slat was deflected. The minimum drag obtainable with the slat deflected was considerably higher than that for the plain wing. A diving moment was incurred, throughout the positive lift range, when the slat was deflected, and this effect generally increased with increasing Mach number up to 1.00. Since the successive test points were recorded at an increasing angle of attack only, it is felt that a hysteresis effect might be present in the pitching-moment curves (reference 3).

The variation of the maximum lift coefficient with Mach number is presented in figure 5. The maximum lift coefficient of the plain wing was considered to be the maximum lift coefficient that occurred below 24° angle of attack. The reason for this was that the pitching-moment curve had a sharp discontinuity rendering the higher lift coefficients unusable for this configuration. The maximum lift coefficient for the wing with the slat deflected was the maximum lift coefficient obtained. From this figure it may be seen that, even though a large increase in the maximum lift was obtainable in the low speed range (approximately 50 percent), the gain effected by the leading-edge slat tested decreases considerably as the Mach number is increased above 0.90. These results are in agreement with those of reference 4, which indicates that although appreciable variation in the value of $C_{L_{max}}$ may be possible at low speed, little or no increase in the value of $C_{L_{max}}$ appears possible at speeds greater than the speed of sound.

CONCLUSION

A wind-tunnel investigation at transonic speeds of a leading-edge slat deflected 40° on a modified-double-wedge wing indicated that, although the slat tested increased the maximum lift coefficient approximately 50 percent at low Mach numbers, it had only a small effect on maximum lift coefficient above a Mach number of 0.90.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va.

REFERENCES

1. McKee, Paul B.: Preliminary Report of an Investigation on the Maximum Lift Coefficient of a 4.5% Thick Supersonic Airfoil Equipped with High Lift Devices. Part II - Various Double Slotted Trailing Edge Flaps Combined with Plain and Slotted Leading Edge Flaps. MR No. MCREXA9-4482-5-27, Air Materiel Command, U. S. Air Force, Nov. 2, 1950.

2. Riebe, John M., and MacLeod, Richard G.: Preliminary Wind-Tunnel Investigation at High-Subsonic Speeds of Planing-Tail, Blended, and Airfoil-Forebody Swept Hulls. NACA RM L9D01, 1949.

3. Johnson, Ben H., Jr.: Investigation of a Thin Wing of Aspect Ratio 4 in the Ames 12-Foot Pressure Wind Tunnel. I - Characteristics of a Plain Wing. NACA RM A8D07, 1948.

4. Lowry, John G., and Cahill, Jones F.: Review of the Maximum-Lift Characteristics of Thin and Swept Wings. NACA RM L51E03, 1951.

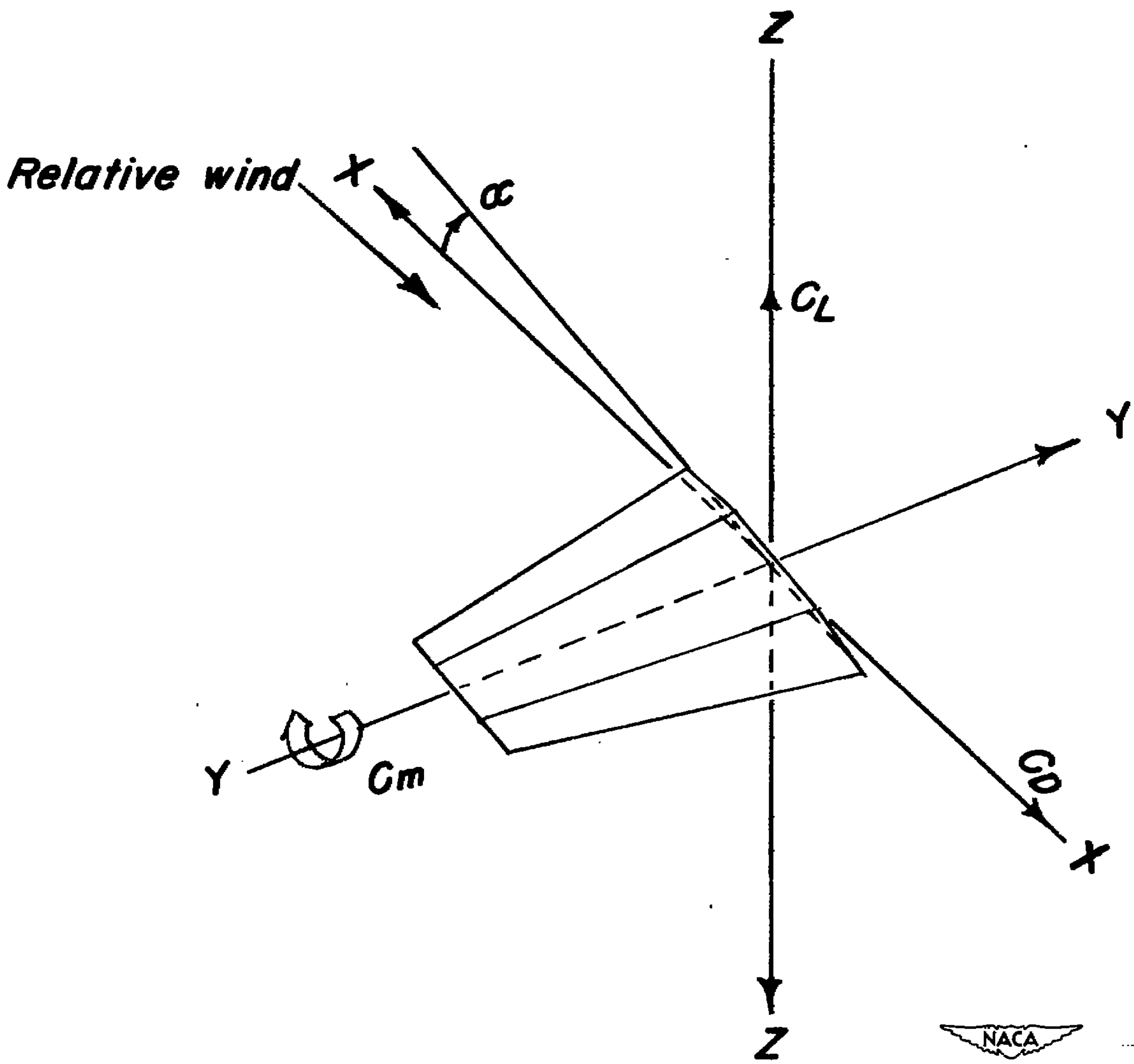


Figure 1.- Systems of axes. Positive directions of forces, moments, and angles are indicated by arrows.

[redacted]

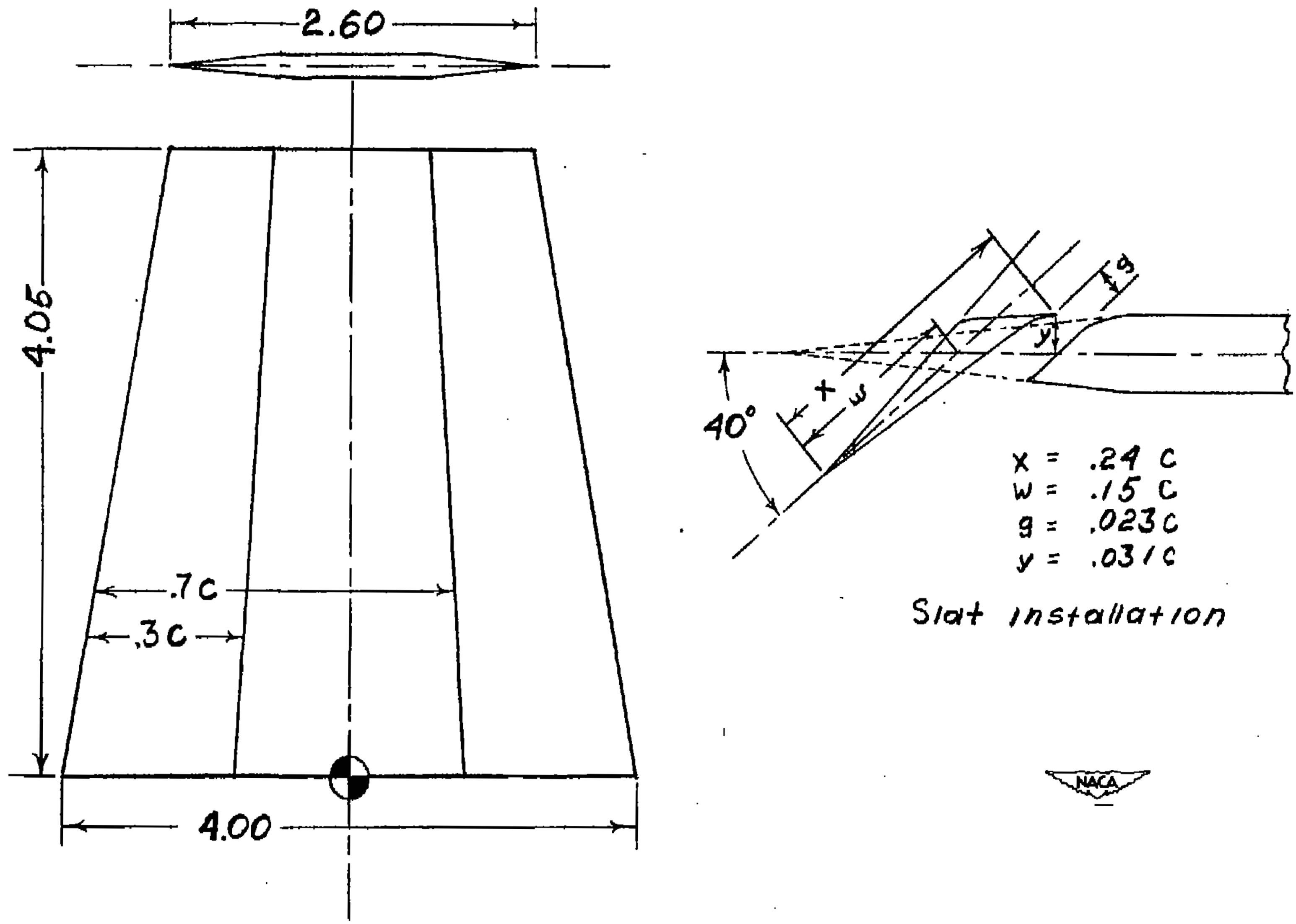


Figure 2.- Geometric characteristics of the test model. (All dimensions are in inches.)

[redacted]

[redacted]

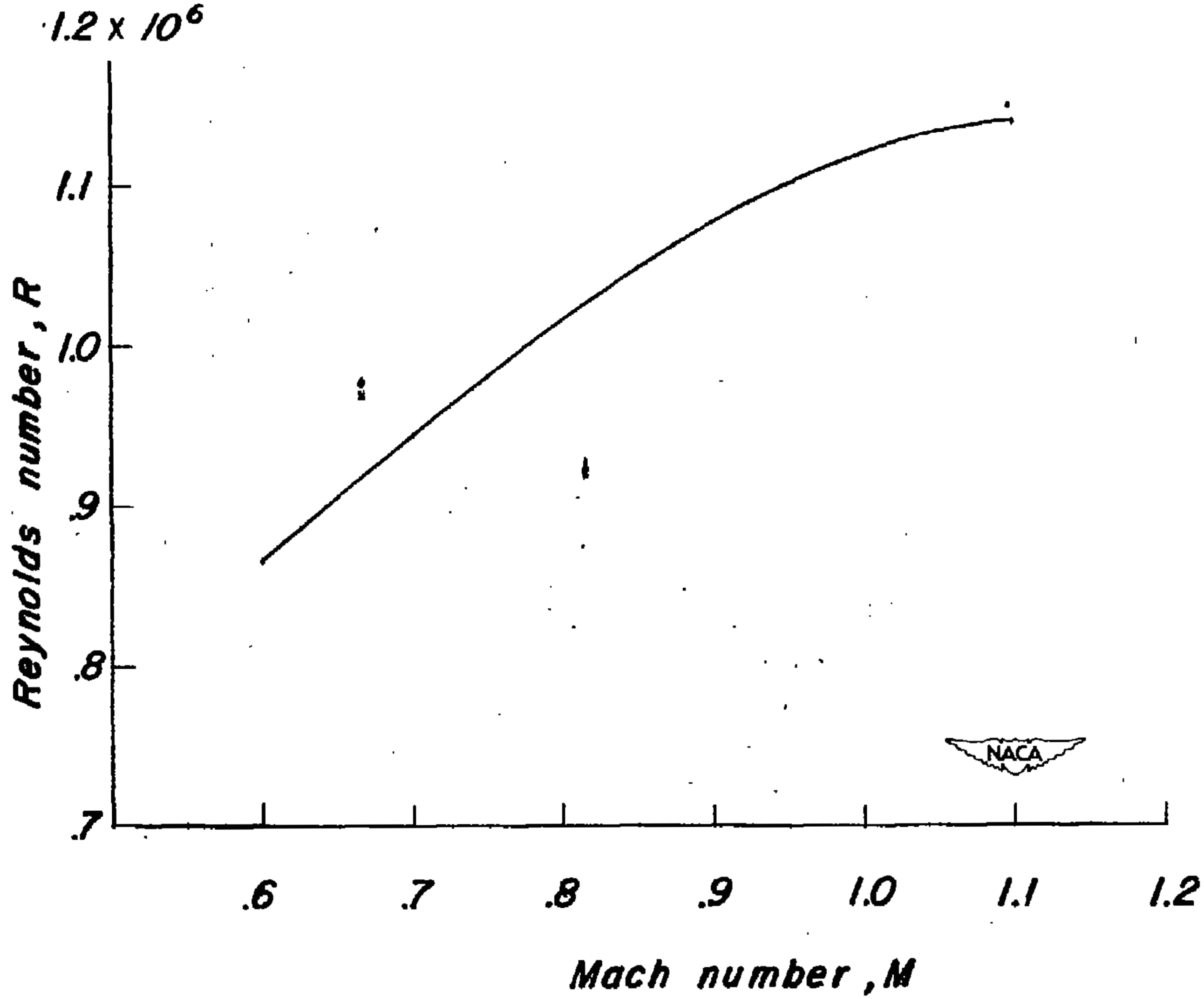
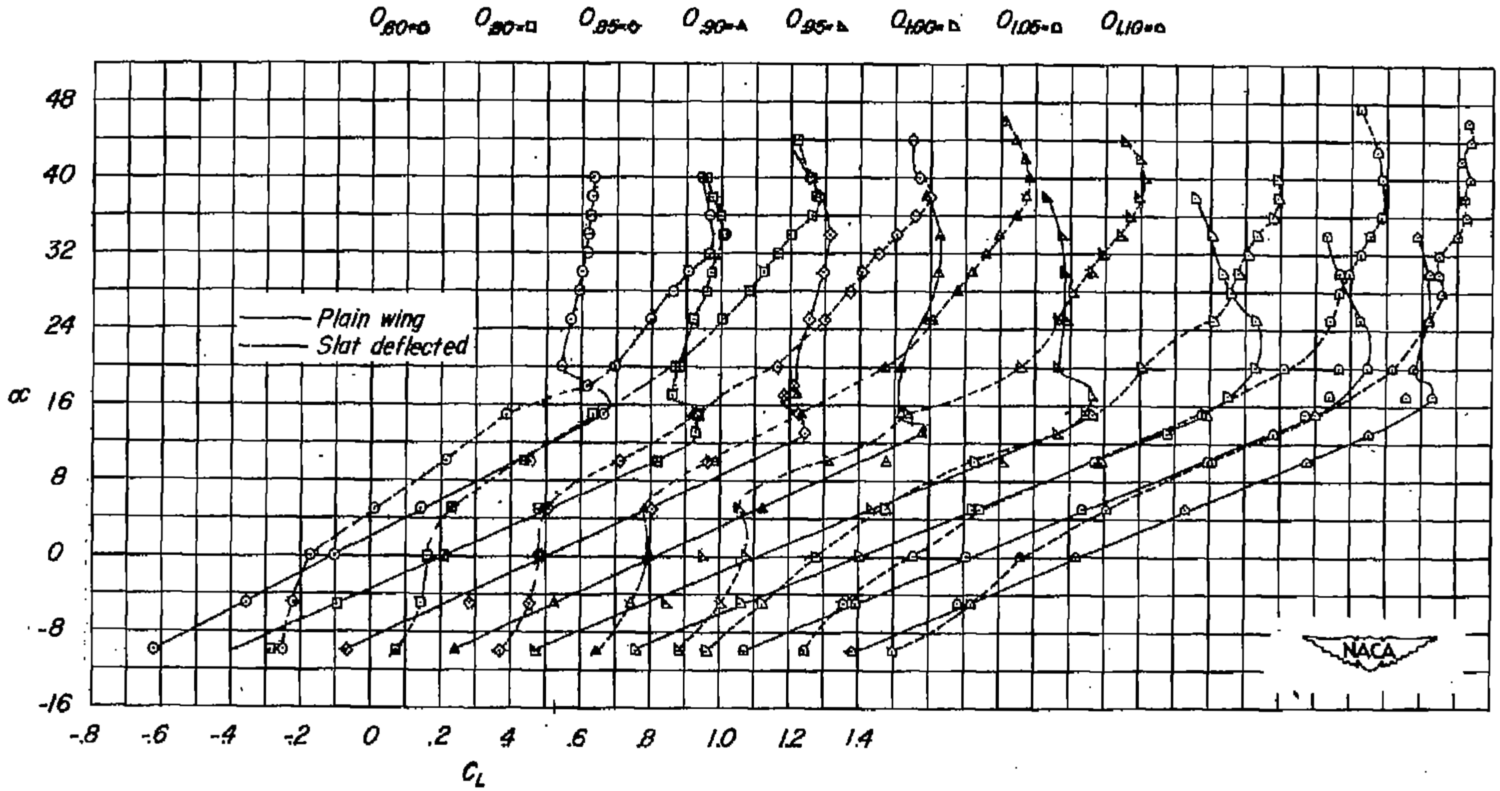


Figure 3.- The variation of Reynolds number with Mach number for the test model.

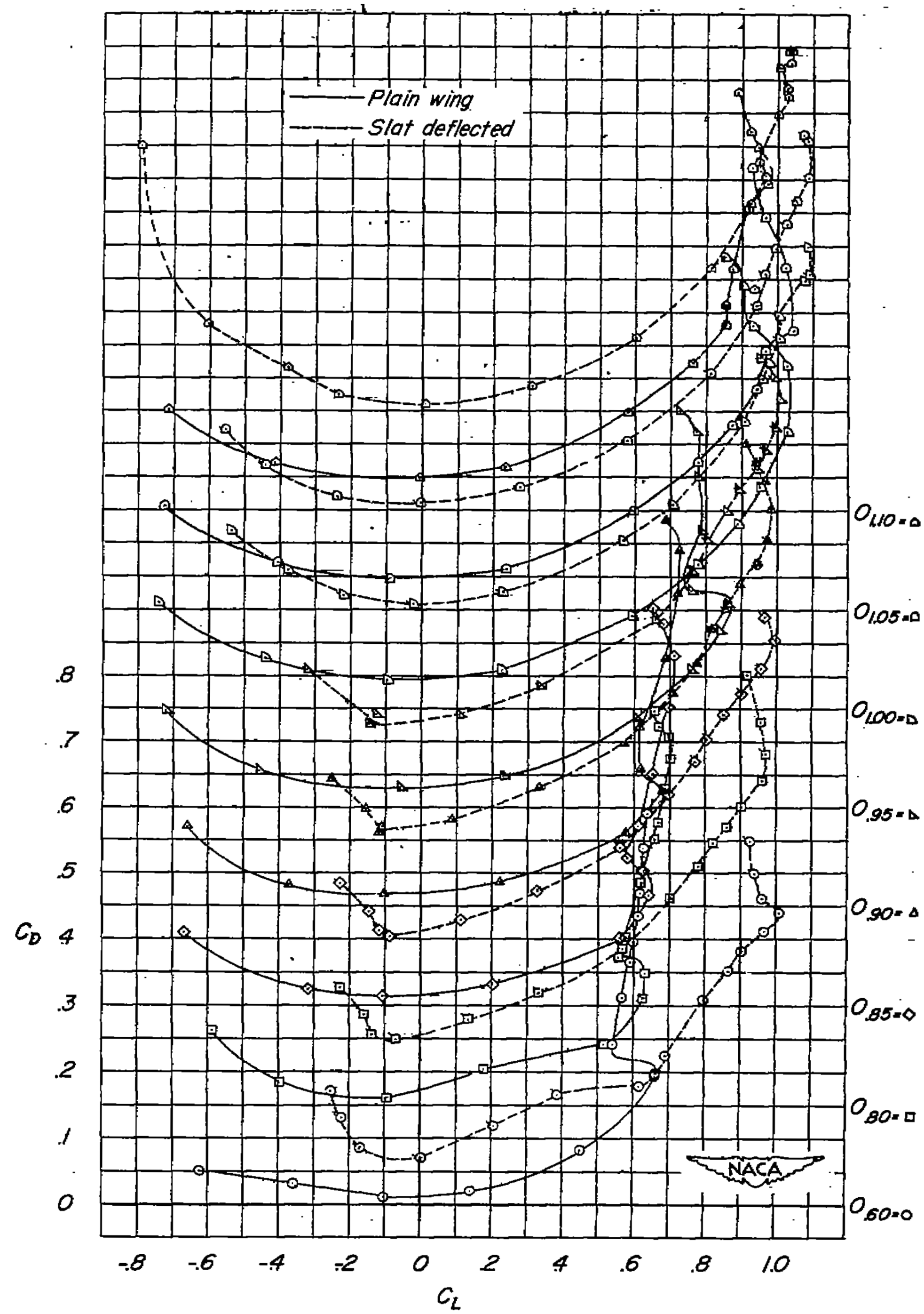
[redacted]



(a) Lift characteristics.

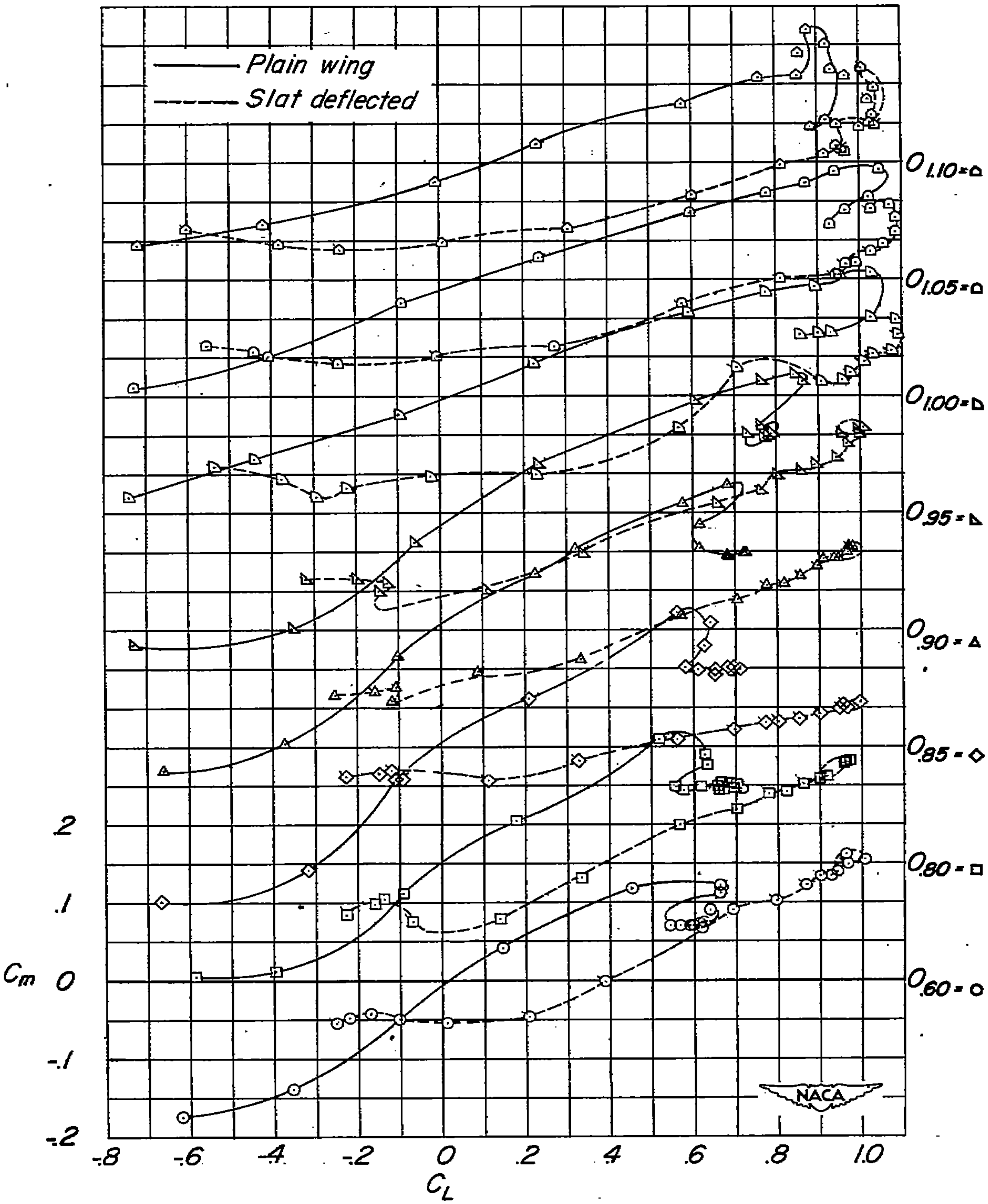
Figure 4.- The aerodynamic characteristics of the test model.

[redacted]



(b) Drag characteristics.

Figure 4.- Continued.



(c) Pitching-moment characteristics.

Figure 4.- Concluded.

[redacted]

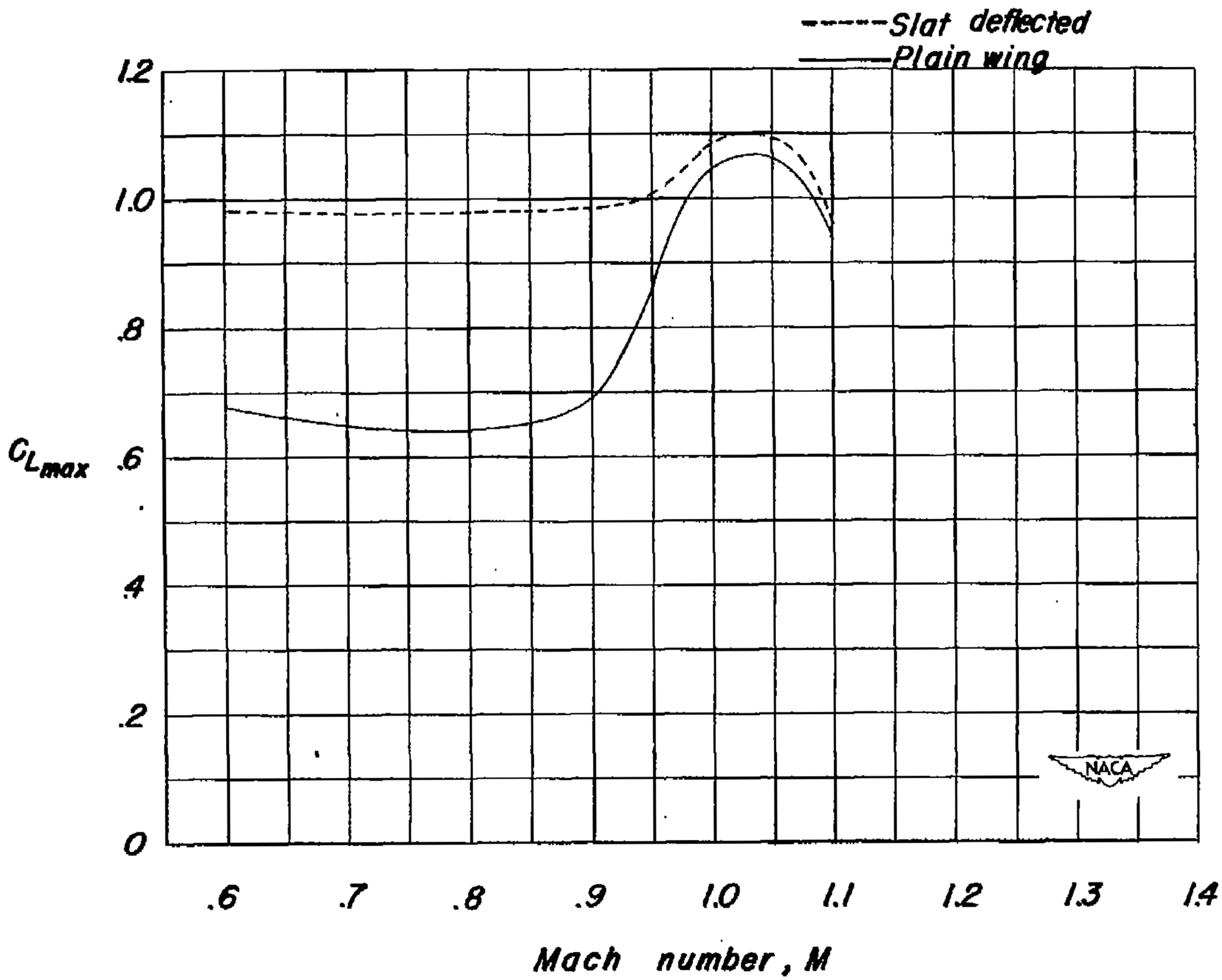


Figure 5.- The effect of a leading-edge slat on the maximum lift coefficient of the test model.

NACA-Langley - 12-26-51 - 335

SECURITY INFORMATION

[redacted]